

### QUESTION

The frequency of the highest note on the piano is 4,186 Hz.

a.) How many harmonics of that note can be heard?

b.) How many harmonics of that note one octave below can be heard?

### SOLUTION

**a)**

If the fundamental frequency is  $f$ , the harmonics have frequencies  $2f, 3f, 4f, \dots$  etc. In humans the audible range of frequencies is usually 20 to 20,000 Hz

So, the fundamental frequency is  $f_0 = 4186 \text{ Hz}$

The first harmonic frequency is 8372 Hz

The second harmonic frequency is 12558 Hz

The third harmonic frequency is 16744

The fourth harmonic frequency is 20930 Hz – out of the audible range.

Hence, three harmonics of that note can be heard.

Or, another way of solving this problem:

As  $\frac{20000}{4186} = 4.77$ , we can hear 3 harmonics (except fundamental), and the fourth

harmonic is out of range.

**b)**

The frequency of this note one octave below is  $f = \frac{4186}{2} = 2093 \text{ Hz}$

As  $\frac{20000}{2093} = 9.55$ , we can hear 8 (except fundamental) harmonics with

frequencies (4186 Hz, 6279 Hz, 8372 Hz, 10465 Hz, 12558 Hz, 14651 Hz, 14651 Hz, 18837 Hz)

### ANSWER

**a) 3**

**b) 8**